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ENGINEERED PERFORMANCE STANDARDS
THEIR APPLICATION AT AN AIRCRAFT
OVERHAUL ACTIVITY OF THE NAVY

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PREFACE

This paper gives a brief and general account of the establishment of engineered performance standard in a Naval Aircraft overhaul activity. It reports in narrative form some of the difficulties encountered in installing standards for that type of work and relates the solutions developed in answer to some of the more complex problems.

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ENGINEERED PERFORMANCE STANDARDS THEIR APPLICATION AT AN AIRCRAFT OVERHAUL ACTIVITY OF THE NAVY

INTRODUCTION

In the Fall of 1951, in response to the national urge to "obtain more defense per dollar expended", the Bureau of Aeronautics adopted as one of its programs the pilot installation of Engineered Performance Standards at the Naval Air Station, Jacksonville, Fla. The program was designed to improve production methods and to realize the maximum utilization of manpower by applying engineered performance standards to the industrial departments at the air station. This paper will limit discussion to the installation of performance standards in the Overhaul and Repair Department (Aircraft, aircraft engine and components overhaul and repair), Naval Air Station, Jacksonville, Fla. The opinions expressed in this paper are strictly those of the author and should not be construed as being the views of the Navy Department.

Before proceeding further the author considers it advisable to define the term "Engineered Performance Standards". The engineered performance standards are relatively precise quotas established by prescribed methods of time study after the work itself has been standardized. To clarify further, an individual job or operation is analyzed to determine: 1) if it is necessary,

then if necessary, 2) if it can be accomplished easier and quicker by means of: a) simplifying motions, b) additional or new tooling, c) correcting work space layout, d) improving work flow or, e) work methods. After the analysis is completed then the job is standardized and the time readings for all elements of the job are compiled. The accepted factors on fatigue, delays and leveling are then applied, and the rate for the job is derived from the total final data. This rate becomes the "standard" for all workers performing the same operation under standard conditions and is known then as the "engineered performance standard."

PHASE I: INSTRUCTION

As mentioned in the introduction the development of an engineered performance standard involves much more than the determination of the time necessary to complete the operation. The engineered performance standard involves the following steps: a) finding the most economical way of performing work, b) simplifying the methods, materials, tooling, and equipment used, standardizing each of these to the extent practicable, c) accurately determining the time required by an average worker to accomplish each element of the job under average conditions, and d) training the worker in the new method. Obviously to accomplish these four steps a well trained group of industrial engineers, methods analysts and time-study men are necessary. There being no such composite group available at the Naval Air Station, Jacksonville, it was necessary to instruct personnel at the station in each of these factors. To instruct the personnel the Bureau of Aeronautics contracted with a management engineering firm, the George H. Elliott Company of New York, to take on the task. The contract called for the Elliott Company to train fifteen men in methods improvement and setting of standards. In addition the contractor was to train line supervision in work simplification, familiarize management personnel in the broad objectives of establishing performance standards and direct the in-

stallation of actual time studied standards in two of the shops in the Overhaul and Repair Department. The fifteen trainees were given a total of 676 hours of instruction, including classroom shop hours, where they were taught the following:

1) Time study
2) Performance rating
3) Work simplification
4) Advanced time study
5) Standard time data
6) Methods-time-measurement
7) Special Shop projects
8) Installation and controls systems

It is interesting to note at this point that the fifteen trainees were selected from approximately six hundred employees of the Overhaul and Repair Department who had submitted applications for the training and that the selection was accomplished by means of a series of mental alertness, mathematical aptitude and personality tests together with personal interviews.

There was a small group of industrial engineers in the organization of the Overhaul and Repair Department whose jobs were, prior to the installation of the engineered performance standards program to advise management on organization, plant layout and to interpret statistical data. This group together with three additional industrial engineers who were hired as the program progressed were given the task of organizing the group of trainees into what was to become the engineered performance standards group. The industrial engineers from time to time attended

lectures and instruction periods conducted by the contractor but primarily they consulted with the contractors engineers in developing an organized group which would carry on the standards program after the contractor was completed with his instruction of trainees and the initial installation of standards.

To assist in the guidance and the coordination of the program throughout the Overhaul and Repair Department, management ordered the formation of an Advisory Board the responsibilities of which were:

a) To formulate guiding policy for the program
b) To recommend solutions to problem areas
c) To make suggestions regarding the course content, schedules and progress of the training program
d) To determine the shops or areas for initial application of performance standards
e) To advise on statistical methods and reports necessary to the program.

This Board which consisted of the top management of the department met with the contractor and the department's industrial engineers on the order of once a week. The Board proved to be of great value in the guidance of the entire program.

Concurrently with the instruction of the trainees, a course in work simplification was inaugurated for the shop supervisory personnel. This course was planned so that it would be carried

out on a continuing basis after the departure of the contractor and gave each supervisor about thirty hours of instruction until all supervisors in the department had received the training. This instruction proved to be very beneficial, not only from the direct gains derived but mainly from the standpoint of improved human relations through the supervisor's ready acceptance of the program and his aid in the installation of the standards in his shop.

PHASE II: THE INSTALLATION OF STANDARDS

Of prime importance in the installation of standards was the job of "selling" the program to all levels of management and to the shops. It was just as important that supervisors, foremen, masters and top management become fully acquainted with the objectives of the program, how it was to be accomplished, how the standards would be developed prior to installation and how they were to be used in the shops, and that the men in the shops be properly indoctrinated.

Occasionally the aims and techniques of a sound industrial engineering program are incorrectly identified with the term "speed-up". It was explained to each of the levels of management and to the workers of each shop prior to the installation of standards that work measurement under the Engineered Performance Standards Program would result in the establishment of time standards representing reasonable attainment by men working at normal performance rates. Normal performance was then defined as the work pace which may be considered consistantly and easily maintainable over an eight hour day. The objective, it was pointed out, is to obtain a fair day's work for a fair day's pay. This was to be accomplished by assisting the individual worker through improved methods and the elimination of delays and interruptions by means of better planned work, thereby permitting the individual to work more hours productively

rather than pressing him to work at a faster pace.

This process of indoctrination was a continuing practice and was not only given prior to installation but was emphasized repeatedly throughout the installation period. As mentioned above, the success or failure of the program was contingent upon its full acceptance up and down the entire chain of the organization.

The installation of standards was accomplished by teams of standard analysts, usually two or three men to a team depending upon the size of the shop and the coverage expected, that is, the extent to which standards would be applied to operations throughout the shop. These standard teams functioned along the following lines. First, their objective was to improve production methods, therefore, they would go into the shop selected for installation of standards and record all details of the job, using flow-process charts, motion charts, methods-time-measurement analysis or other means which they would develop. Second, each detail of the job was questioned, that is, they would ask: "Was it necessary? What methods and sequence of operations were necessary? What is the relationship to other processes in shop? When should the operation be performed in relation to other operations?" Third, a study was conducted of the work conditions, the shop layout, the materials handling, the movement necessary and the tools and equipment available.

Fourth, from the above information the best method, work conditions and layout for the job were established and the method then described in written form, by elements. The fifth and last step was to record the time for the elements of the operation, using time and motion study, synthesis from past records or methods-time-measurements. To this elemental time data were added personal, fatigue and supplemental time allowances and the result was the standard time allowed for the job. It is hoped that the reader will not consider the establishment of standards as an easy task from the rather brief and sketchy details given here. Actually the time and motion studies necessary to obtain standard data are extremely detailed, voluminous and time consuming. They represent the correlation of an extensive amount of detail and study prior to actually setting the standard.

During the above period the team of standard analysts worked closely with the supervisors in the shops in which they were making the surveys and of course with the individual workers as well. It was upon the shoulders of the analysts that the burden of the "selling job" mentioned previously, fell. If they ran into difficulty the industrial engineers were called in. Then if the difficulties were not settled a meeting of top management and all the parties concerned was

held and an agreement or arbitration evolved.

When once the standards were developed and agreed to by the workers who were to use them the next step in the installation was the establishment of a suitable reporting system or means of control so that performance could be measured against the standard. To accomplish this control four reports were used. The first report, the job/time card, was used to enter the data accumulated by the shop timekeeper. The job/time card was used for daily recording of the time spent by employee on particular operations, the collection of accurate labor cost, the collection of production completions, and precalculation of labor effectiveness. The card showed part number, job order number, units completed, time per unit, elapsed time and a summary of labor distribution by type of cost. This card was not a report for use by management but provided source data for reporting individual performance in the shop. The second report, the daily and weekly production report, showed all work performed by each worker including that not covered by standards which was listed in a separate column. The time which the worker spent on standard work was compared with the standard established for the job and his performance rate was then listed on this report. Also shown in the report were the percentage of the shop operations covered by standards and the shop's performance rating. The same form was used to show both the daily and weekly pro-

duction status. The production report provided immediate daily labor control information for use by the shop supervisors. The third report, the weekly labor analysis report, was an integral part of the control system because it gave information by which improvement or contrariwise the lag in production was measured. In this report costs were converted to cost per standard dollar for the week which was then compared with past performances to determine the trend in costs. Comparison of costs between shops could be made since all costs were reduced to a common demoninator--the cost per standard dollar. The fourth and final report, the performance report, presented in summarized form the digested data of the weekly labor analysis report so that top management would have at hand, for corrective action if necessary, the information on favorable or unfavorable performance trends. The performance and labor analysis reports supplied complete significant labor cost data for top and middle management control. These reports were used primarily for reduction of excess payroll costs, control of standard costs and comparison of current shop trends.

The philosophy underlying any control system is that corrective action, based on analysis of the factors causing irregularities, will be initiated at the lowest possible management level. The reports listed above were designed to give management the timely factors on the status of production and also the trends, so that the proper executive action might be taken.

EVALUATION OF POSITION AT THE END OF TRIAL PERIOD

Briefly the operations of the Overhaul and Repair Department are, the disassembly of the airplane as it comes into the overhaul shop, routing, tagging and deciding the work to be accomplished on each of the component parts, and the processing of these parts in the various shops such as metalsmith, electric overhaul, electronic overhaul, aircraft engine overhaul, aircraft assembly and finally flight test and inspection. In each of the major shops listed above a further processing goes on, such as disassembly, subrouting to process shop, repair, assembly, test and inspection. The tremendous number of these processes, probably each of them varied from a slight degree to a major extent as they are applied to the twenty different types of aircraft which were to be overhauled, will help to give the reader some appreciation of the extent of the coverage necessary and the task to complete an installation of standards.

By June 30, 1952 the management consulting contractor completed his contract which was first, to train the group of standards analysts so that they would be capable of performing the function of time study engineers and secondly, to actually install standards in two shops and render assistance to the Navy in establishing standards in a third shop. At this stage the Navy has to drop the "pilot" in the form of the consultants and proceed on the performance standards program under their own steam with

the crew trained by the contractors. There were now thirteen trained standards analysts available to carry on the program and to supplement this group in the future a course of training in engineered standards was to be conducted by the Navy for the training of additional analysts. An estimate was made at this time as to the length of time which would be required and the number of personnel required to staff the standard groups in order to complete the installation of standards in all shops. As a result of this analysis it was determined that with a group of approximately forty standards analysts it would take about five years to complete the installation.

It must be remembered that the interest of all the employees of the department in this engineered performance standards program had been initially aroused and continually fired up by periodic reports of progress to all workers. This policy in itself aided production and also created a spirit of cooperative acceptance of the program among the workers. It was realized, however, that a program which would take five years to complete would negate the effects of this spirited cooperation and that therefore management must find a solution in order to maintain the interest in the program and to retain continued worker interest. Management then reviewed the status, the results obtained so far, the good and poor features of the program, and decided on a course of action. The various problems, deficiencies and salient good features of the

program are discussed in the next few pages.

From the inception of the program it was recognized that one hundred percent coverage in any one shop was impossible, that is, it would be impossible to have standards on every last operation of process performed in a shop. The estimates varied from ten percent to ninety percent coverage possible in the various shops throughout the department. Of course when a shop is only partially on standards the task of recording and computing time as applied to that part of a job for which standards exist, becomes complicated. Coupled with this problem was the fact that the percentage of standards coverage in any one shop would vary from day to day and week to week. This was possible because of the constant changes in the type of workload in the shop, casued by the variety of models of planes overhauled. As an example, the hydraulics shop might be overhauling oil coolers for fighters for three days of the week and have standards in effect for those coolers. This workload together with the other work on standards in the shop might represent fifty percent of the workload for these three days; therefore, the shop would be considered fifty percent on standards or have fifty percent coverage. Now if on the last two working days of the week there were some fleet work or other items for which there had been no standards established and if this work were substituted for the oil coolers, one can readily see that the percentage coverage in the shop will be decreased.

One might also ask, "What difference does that make?" If the coverage varies appreciably then the reporting system becomes far less effective. The reason for this loss of effectiveness is that the management levels for whom the reporting system is designed are not able readily to detect from the reports the individual or shop efficiency because of lack of ability to compare the current productivity with past performance since there is no common base for comparison.

When a shop is only partially covered by standards it is not longbefore the employees learn that they are able to obtain high productivity rates on that portion of the work for which standards exist. There are many devious ways of obtaining this result, the most common being that set-up time, or prior operations on a piece of work may be accomplished while on "day work" prior to "going on standard". "Day work" is all work which is not on standard; therefore since there usually is no accurate measure of "day work" available (otherwise it would be on standards) the employee is able to do some of his "standard" work on "day work" time without the likelihood of being caught. In this manner he is able to maintain high productivity rates for his "standards" work and thus keep the supervisor from remonstrating with him. In fact this loophole in the system enables the marginal type supervisor to slack off on his job because the reports going to management would indicate

that his shop is maintaining a high efficiency when the exact opposite may be true. Some unscrupulous supervisors would even aid and abet employees to follow the above practices.

As mentioned above, the daily production report listed the individual workers by name, giving the number of standard minutes per hour which were achieved by the worker for the time worked on standards that day. The standards were so developed that the employee who averaged sixty standard minutes per standard hour for the time or standards was considered to have done a "fair day's" work. One who averaged more than sixty standard minutes accomplished over and above a fair day's work and of course those below did less than a fair day's work. When the reporting system was first placed in effect and the daily production reports posted, each individual worker was able to note not only what his average standard minutes for the day were but could note the average which his co-workers obtained as well. In fact the daily production reports were issued with the name of the worker who turned in the highest number of standard minutes per day at the top of the list and the rest of his co-workers listed in descending order. During the first few weeks of operation there was a reasonable spread in workers' efficiency, as noted on the daily production reports, of from thirty-five or forty standard minutes per hour to one hundred minutes per hour in the case of one or two individuals. In a very short period of time, however, the range of efficiency between

workers narrowed to a point where there were but one or two in each shop above sixty standard minutes and only one or two below the sixty. In these instances where they were above or below sixty standards minutes the men would only be two to four minutes either side of sixty. It was apparent then that these daily reports were having a detrimental effect on productivity for as one could suspect, there would normally never be that narrow a range in efficiency among workers. In all probability the efficient workers were either not reporting the true time worked on standards or were slowing down so as not to be considered "eager beavers" or "apple polishers" by their co-workers and the in-efficient were probably doing standard work on day work and not charging the proper time to standards, in order to bring up their reported efficiency standing. In any event it was obvious that, the reporting system was not accomplishing the purpose for which designed, that the employees were learning ways and means of defeating the system and thereby nurturing a disrespect for the possible accomplishments of the program and lastly that the basic purpose, namely, improving over all efficiency, was being defeated. Management discussed this problem of the narrowing range in productivity, with the supervisors and the workers but in each instance these men gave some extraneous, irrelevant excuse as their reason for the lowering of efficiency of those who at first were noted to be of above average efficiency. Of course

each pointed to the increase in efficiency of those who were below sixty. It was apparent that the posting of the individuals daily standing among this group of co-workers was defeating the system, therefore, the report was suspended until such time as an adequate substitute could be developed.

Earlier in this paper, it was very briefly pointed out that there was an immense amount of detailed study involved in developing a standard and that "selling" the standards to the production workers required additional time. In view of the results obtained it was extremely questionable as to whether the savings (time savings, that is) warranted the amount of time and energy spent on developing these standards. True, in shops where there were highly repetitive operations and where the changes in workload were not too frequent, there was opportunity to cover the shop to the extent of it becoming ninety to ninety-five percent on standards. Shops of this nature are few in number in the business of overhauling and repairing aircraft. As developed and discussed above three outstanding difficulties faced management in connection with the progress of the engineered performance program. These were, one, what to do about the fact that it would take five years to cover the shops in the overhaul and repair department with standards, two, what to do about the reporting system, and three, what to do about shops in which standards coverage would at best be at a low percentage or where the establishment of standards under this

system was too costly for the savings realized. In developing a solution to the first of these problems, the third problem was solved automatically. As mentioned above management recognized that interest in the whole standards program would wane very rapidly if it was generally known that five years would be required to install the program completely. Therefore, it was decided that a "quick coverage" program was required.

THE NEW CONCEPT -- THE QUICK COVERAGE PROGRAM

The "quick coverage" program as developed consisted of teams going into shops, with the objective of achieving maximum coverage of the shops activities within the shortest possible time. These teams consisted of top flight production, inspection, planning and industrial engineering personnel together with at least one top flight member from the shop in which the coverage was being performed. Emphasis was placed on the careful selection of personnel for these teams because first of all they had to be recognized by the employees as men who knew their trades, knew "how it should be done" and men who were therefore respected. Because they were co-workers they would therefore be accepted as the employees' representatives. This was a necessary part of the "selling" job to insure that resistance to the "new" standards would not develop. At this time it was also considered advisable to change the name of the term standard as it had been used. Instead, the term "control figure" was used, indicating that it was to be used for the purpose of controlling production.

For purposes of installing the quick coverage program the department was divided into two segments (not physically of course) namely, 1) the main highway and 2) the processing shops. The main highway consisted of such shops as disassembly, fuselage assembly, flight test, and final paint. These were shops in which work on the entire airplane was accomplished as it proceeded through

overhaul. The processing shops were considered to be such shops as would handle the accessories, parts and components. The shops in the main highway after a quick study, appeared to be most fruitful from the standpoint of achieving savings in manpower and material, therefore, initial emphasis was placed on covering these shops first.

The quick coverage teams operated as follows:

1) Studied present methods and operations and when developed the optimum sequence of operations and installed these refinements.
2) Timed operations under the new methods developed in 1) above.
3) Identified the operations in writing so that the job would be clearly understood by all.
4) Balanced the total process or job for the best results by dovetailing the workers by trade and operation at any one station so that one worker would not be standing around waiting for the next airplane or waiting until his co-worker completed the job he was working on. This balancing of operations proved to be a very valuable means of saving man hours.

The "quick coverage" program then, was the solution evolved by management to the two problems of what to do about the fact

that installation of engineered performance standards throughout the department would have taken five years and secondly what to do about shops in which the standards coverage would exist only on a small percentage. Perhaps a discussion of the effectiveness of the "quick coverage" program with relation to the latter of these two problems would be in order. As noted previously either changes in workload or the fact that the operation in a particular shop did not lend themselves to detailed engineered performance standards application accounted for only partial standards coverage within a shop. The "quick coverage" program, as applied, covered the entire shop by obtaining performance data for a shop as a unit rather than depending upon detailed engineered standards of the many individual operations. In other words larger segments of work were measured with less emphasis on the detailed operation. In this manner "day work" and work which would have been under engineered standards were lumped together and the term control figure applied to the result. In effect these too were standards but not on the same refined scale as were the engineered standards.

Having developed solutions to two of the problems there remained the problem of designing and installing a satisfactory reporting system which would be devoid of the disadvantages and the objections contained in the original system. It was apparent that a reporting system which would require the posting of standings in

individual effort for the day was ineffectual and actually promoted inefficiency. The workers were compared individually in this sort of a system, and the beneficial effects of team-work effort were lost. In addition the system of reporting on individual effort had the effect of depriving supervisors of their supervisory powers and management effectiveness. It was obvious then that a system must be devised which would again promote team work action and give supervision the opportunity to exercise management control over their employees. It was decided that a weekly report which would depict the efficiency or effectiveness of the entire shop as a unit would accomplish the objectives of management and serve as a solution to the problems presented by the use of the original reporting system. In addition the weekly shop effectiveness report would result in a decided savings in clerical and timekeeping man-hours.

The weekly shop effectiveness report was designed so that it would give the reader a report on the past 14 consecutive weeks' effectiveness. The report was made as simple as possible and included not only the figures on effectiveness but also a line graph of the effectiveness for the past 14 weeks. The report showed the direct man-hours expended, the earned or control figure man-hours, and the computed effectiveness which was the ratio of these two figures. The report showed the indirect man-hours expended, the earned indirect man-hours and the effectiveness in indirect

man-hours which was the ratio of the figures above. Then the combined expended and earned man-hours were used to compute the total shop effectiveness and this effectiveness was shown in percentage form and plotted on the graph. A sample shop effectiveness report is included herewith as enclosure11.

Using this new shop effectiveness report, supervisors and management could tell at a glance the relative effectiveness of the particular shops involved and take necessary corrective action where called for. These reports could then be combined to give the collective shop effectiveness of a whole division.

The "quick coverage" program together with the installation of the weekly shop effectiveness reporting system overcame the objections and the difficulties which were encountered during the initial installation of the engineered performance standards program. The quick coverage program will probably take one year to cover the entire department but the main highway and the larger processing shops were covered first, thereby reaping the larger gains in man-hour savings at the start. The detailed engineered performance standards are being developed continously and are being used to replace the control figures obtained by quick coverage wherever they are applicable.

The combined programs of quick coverage and engineered performance standards have proved to be highly successful and have resulted in the following savings in man-hours:

These savings in man-hours are sufficient proof in themselves of the benefits derived from the program.

Results in Selected Shops
July 1952--January 1953

ITEM	PRE STANDARD TIME	POST STANDARD TIME	PER CENT INCREASE IN PRODUCTIVITY
ENGINE CYLINDERS	2hrs18½min	1hr40min	38.3%
HYDRAULIC VALVES	1hr6min	42min	57.2%
OIL VALVES	2hrs54min	1hr48min	61.2%
PACKAGING	27½min	17min	63.5%
ENGINE ASSEMBLY	76hrs45min	43hrs12min	77.8%
AIRCRAFT DISASSEMBLY	137hrs55min	70hrs	97.0%
AIRCRAFT ASSEMBLY	806hrs3mins	481hrs36min	67.5%

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